Perceptions and Beliefs influencing intention to use solar energy solutions in Zambian Housholds

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Abstract

Purpose: The study examined perceptions and beliefs that influence the intention to adopt solar energy solutions in the Zambian Housing Sector. This is important because empirical evidence for measures aimed at improving the adoption of solar energy solutions with SSA in general or a Zambian context, in particular, are largely missing from the literature.

Methods: Hierarchical multiple linear regression was used to analyse quantitative data collected through an online questionnaire survey. A total of 947 valid responses were obtained from a convenient sample of household heads.

Results: The results show that attitude towards solar energy solutions, subjective norms, perceived benefits, perceived trust, knowledge about solar energy solutions, load-shedding and social norms, in that order of magnitude, influence the intention to adopt solar energy solutions. Perceived behavioural control, perceived risk and perceived cost did not influence the intention to adopt solar energy solutions.

Originality: The results provide empirical evidence of important factors to drive the adoption of solar energy solutions in Zambia. The results further show that knowledge about available solar energy solutions, rather than general knowledge about renewable energy, influence the adoption intention of solar energy solutions.

Keywords: Load-shedding, Perceptions and beliefs, Renewable energy, Solar energy

Introduction

The African continent has the potential to enhance the use of solar energy. It has the highest global horizontal irradiation (GHI) and direct normal irradiation (DNI) (Baurzhan and Jenkins, 2016; Prăvălie, Patriche and Bandoc, 2019). This gives Africa the highest potential for solar energy generation globally. However, solar energy generation accounted for less than 3 percent of the continent's energy in 2018 (Schwerhoff and Sy, 2020). While the huge electricity potential from solar energy generation remains mostly unexploited, it is not from a lack of demand. For example, only about 22 percent of households are connected to Zambia's national electricity grid (Kesselring, 2017). Generally, sub-Saharan Africa (SSA) has an electricity installed capacity of about 0.1 kW per capita compared to between 1.0 and 3.3 kW per capita for wealthier nations

(Avila *et al.*, 2017). There is, therefore, a significant potential to fill this electricity supply gap with the abundant solar energy.

However, concerns have been raised about the financial feasibility of solar energy systems, especially in low-income households (Baurzhan and Jenkins, 2016; Grimm *et al.*, 2020; Ouedraogo, 2017). Notwithstanding, Sievert and Steinbuks (2020) found that off-grid solar systems provide the highest utility for households at low-income levels in poor SSA households. It is also argued that solar energy solutions may be the only realistic solution for these households due to availability and utility (Alrashoud and Tokimatsu, 2019; Qureshi, Ullah and Arentsen, 2017).

However, the use of solar energy solutions is still very low in SSA. It has been argued that the adoption of off-grid solar systems is influenced by technical or financial factors and societal practices (Boamah and Rothfuß, 2018). It was also found that household intention to use renewable energy devices was influenced by moral norms and informational influences (Fornara *et al.*, 2016). In Pakistan, Qureshi, Ullah and Arentsen (2017) found that cost was the most significant influence on the adoption of solar systems among households. In Zambia, it was concluded that institutional factors were the main challenges affecting the adoption of renewable energy (Kachapulula-Mudenda *et al.*, 2018).

In order to improve access to electricity and considering the low levels of electrification in the SSA region in general and Zambia in particular, it is important to understand the reasons for the low levels of adoption of solar energy solutions. While several studies have reported factors that influence the adoption of solar energy solutions, there is a paucity of studies with the specific contextual background of SSA and hardly any specific to Zambia. Further, even with some of the extant literature, there are conflicting results on factors that influence the adoption of solar energy solutions. For example, some studies found that perceived behavioural control (PBC) influences the intention to adopt solar energy solutions (Jabeen *et al.*, 2019; Lundheim *et al.*, 2021; Perri, Giglio and Corvello, 2020; Ru, Wang and Yan, 2018) while others (e.g. Abreu, Wingartz and Hardy, 2019; Huang *et al.*, 2020) did not. Some studies found that subjective norms significantly influence the intention to adopt solar energy systems (Jabeen *et al.*, 2019; Korcaj, Hahnel and Spada, 2015; Perri, Giglio and Corvello, 2020; Ru, Wang and Yan, 2018), while others did not (e.g. Abreu, Wingartz and Hardy, 2019; Lundheim *et al.*, 2021). Therefore, solutions to address the issues surrounding low adoption levels of solar energy solutions may not be directly imported without considering the contextual background.

Therefore, this study explored perception and belief factors that influence the intention to adopt solar energy systems in Zambia. This is important and necessary because factors that are specific to the context of SSA, and Zambia in this case, could guide decision-makers on how to increase the adoption of solar energy solutions in the region. The study first identified factors from the literature that were reported to influence the decision to adopt solar energy. The factors were then formed into a questionnaire, and data were collected from household heads. Hierarchical multiple linear regression was used to establish which of the factors were important in the decision to adopt solar energy solutions in Zambia. Results from the study are of relevance to stakeholders who want to promote the use of solar energy solutions in Zambia and other SSA countries which share a similar contextual background.

Factors influencing the intention to adopt solar energy solutions

Several studies have reported the factors which influence the decision to adopt solar energy solutions. One common theoretical framework adopted in these studies is the theory of planned behaviour (TPB) (e.g. Abreu, Wingartz and Hardy, 2019; Jabeen *et al.*, 2019; Kim *et al.*, 2014; Korcaj, Hahnel and Spada, 2015; Lundheim *et al.*, 2021; Perri, Giglio and Corvello, 2020; Ru, Wang and Yan, 2018). In this regard, the theory's standard constructs are assessed for their predictive power of the intention to adopt solar energy solutions. The constructs assessed using the TPB are attitude towards solar energy solutions, PBC and subjective norms. Findings from studies on PBC and the intention to adopt solar or renewable energies are inconsistent in some instances.

PBC is the perceived level of control over factors that would otherwise impede engaging in a behaviour (Ajzen, 1985, 1991; Ajzen and Cote, 2008; Ajzen and Fishbein, 1970). Its relevance to behaviour prediction is premised on the rationality that the more control one has over factors that would otherwise hinder engaging in a behaviour, the more likely they will be to engage in that behaviour subsequently. Some studies have found that PBC significantly influences the intention to adopt solar energy solutions (Jabeen *et al.*, 2019; Lundheim *et al.*, 2021; Perri, Giglio and Corvello, 2020; Ru, Wang and Yan, 2018), while others find no significant association (Abreu, Wingartz and Hardy, 2019; Huang *et al.*, 2020). For example, in a sample high on PBC, Lundheim et al. (2021) found that PBC had the most significant influence on the intention to adopt solar energy solutions. However, in a study where PBC was very likely to be low, Huang et al. (2020) found that PBC did not have an effect on the use of solar energy. It could be that populations low in PBC would exhibit little to no effect on behavioural intention, while populations high in PBC would exhibit a high behavioural intention. This argument seems to be consistent with results from Ru et al. (2018). However, contrary to this argument, Abreu et al. (2019) found that PBC did not influence the intention to adopt solar energy solutions in a sample from America where the demographics suggested that it would be high on PBC. Therefore, the argument that the level of PBC may be the cause of conflicting results on the influence of PBC on the intention to adopt solar energy solutions only partly explains the inconclusive results pertaining to PBC. This study contributed by assessing whether PBC would influence the intention to adopt solar energy solutions in a country where PBC is expected to be low.

Attitude has also been found to influence the intention to adopt solar energy solutions. Attitude refers to "the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question" (Ajzen, 1991). Attitude appears to consistently predict the intention to adopt solar energy systems (Abreu, Wingartz and Hardy, 2019; Jabeen *et al.*, 2019; Kim *et al.*, 2014; Korcaj, Hahnel and Spada, 2015; Lundheim *et al.*, 2021; Perri, Giglio and Corvello, 2020; Ru, Wang and Yan, 2018). Extant literature seems to have substantially validated the relevance of attitude on the intention to adopt renewable energy technologies. Therefore, attitude is an essential predictor of behavioural intention, and so it still merits examination given its importance.

Subjective norms have also been found to influence the intention to adopt solar energy solutions. Subjective norms are social factors that refer to the perceived social pressures to either undertake a particular behaviour or not. Subjective norms are based on the perceptions of the beliefs of important revered people on the behaviour in question (Ajzen, 1985; Ajzen and Cote, 2008; Ajzen and Fishbein, 1970). The relevance of subjective norms in predicting behaviour intention is premised on the argument that the social pressure emanating from revered individuals induces increased intent to engage in the behaviour. Some studies have found that subjective norms significantly influence the intention to adopt solar energy systems (Jabeen *et al.*,

2019; Korcaj, Hahnel and Spada, 2015; Perri, Giglio and Corvello, 2020; Ru, Wang and Yan, 2018), while others have not (Abreu, Wingartz and Hardy, 2019; Lundheim *et al.*, 2021). All studies which found a significant association had samples drawn from relatively affluent populations. For example, Jabeen et al. (2019) sampled an affluent population in Pakistan, while Perri et al. (2020) conducted their study in Italy and ensured that the relevant stratification of the population was maintained. Studies by Ru et al. (2018) and Korcaj et al. (2015) are similarly based on affluent populations, and all these studies found that subjective norms influence the intention to adopt solar or renewable energies. However, Huang et al. (2020) sampled a poor area of rural China and found that subjective norms did influence the intention to use solar energy. It may be the case that the effect of the perception of important revered people may be stronger in more affluent populations. This may be because affluent individuals may more readily identify with and envy important revered people than the less affluent. However, this argument may only partly explain the conflicting results because Abreu et al. (2019) sampled a population that may be considered affluent but found results contrary to the proposed argument. The current study contributed to this lacuna by assessing whether subjective norms influenced the intention to adopt solar energy solutions in a relatively affluent population in a developing country.

Literature also shows that the concept of social norms has inconsistent findings in studies on the intention to adopt solar energy solutions. Social norms are personal feelings of moral obligation to act or behave in a particular way (Ajzen, 1991). The extent to which someone feels morally obliged to behave in a particular way influences their behavioural intention. Abreu, Wingartz and Hardy (2019) (Ajzen 1991) and Lau *et al.* (2020) found that social norms influence the intention to adopt solar energy systems, while in Italy, Fornara *et al.* (2016) only found an indirect association. Fornara et al. (2020) acknowledged that their results might have been affected by, among other limitations, state incentives to invest in solar energy.

On the other hand, Lau et al. (2020) conducted their study in Malaysia, where the adoption rate for solar systems is very low. The difference in contexts of these two studies may explain the conflicting results. Therefore, because the present study is contextually close to the study by Lau et al. (2020), it was expected that social norms would have a significant influence on the intention to adopt solar energy. This would suggest that the effect of social norms on behavioural intention may be affected by contextual factors. However, even this argument should be taken with caution because Abreu et al.'s (2019) study was based on a survey of American homeowners whose context may not necessarily be similar to Malaysia but found similar results. Therefore, it is unclear why some studies found a significant influence of social norms on intention to adopt solar energy solutions while others did not. The current study contributed to this research gap by assessing the influence of social norms on the intention to adopt solar energy in a context without significant government economic incentives to assess the assumption that moderating factors such as economic incentives may weaken the influence of social norms.

While it would be expected that perceived benefits relating to the use of solar energy systems would influence the intention to adopt them, Irfan *et al.* (2021) found that beliefs about the benefits of renewable energy did not significantly influence the intention to adopt renewable energies. This was in a study that examined factors influencing the adoption of renewable energy. Irfan et al. (2021) considered benefits accruing to society generally instead of benefits accruing to the individual. Therefore, the results were attributed to low levels of knowledge about renewable energies leading to a lack of understanding of the benefits. The current study used a sample that is relatively knowledgeable about solar energy solutions and their benefits. Therefore, the study

contributed to this lacuna by assessing the effect of knowledge in relation to how perceived benefits influence solar energy uptake intention.

The cost of solar energy systems has reduced by about 77% in the last two decades (Schwerhoff and Sy, 2020). With such a significant reduction in cost, it is expected that the adoption of solar energy systems would rise accordingly. However, studies have found that cost negatively influences the intention to adopt solar energy systems (Irfan *et al.*, 2021; Jabeen *et al.*, 2019; Kim *et al.*, 2014; Qureshi, Ullah and Arentsen, 2017). Considering the continued decline of the cost of solar energy systems, it is worthwhile to assess the effect of cost on the intention to adopt the systems.

Studies on the effect of knowledge on the intention to adopt renewable energy systems have reported some inconsistent findings too. For example, Huang *et al.* (2020) found that literacy training had a significant influence on the intention to use solar energy. On the other hand, Jabeen *et al.* (2019) found that environmental knowledge and awareness did not influence the consumers' intention to use renewable power generation technologies. The conception of knowledge by Huang et al. (2020) was information about solar energy solutions, which was not common in the population of interest. However, Jabeen et al. (2019) focused on knowledge and awareness about the environment in relation to renewable energy. Therefore, in the two studies, the concept of knowledge was not the same and hence the different results. The current study operationalised knowledge akin to Huang et al. (2019).

Inadequate electricity supply has been found to influence the intention to adopt solar energy solutions because of the resulting power rationing called load-shedding (Kazmi *et al.*, 2019). Load-shedding is the wilful disconnection of electricity power supply due to generation shortfalls in order to maintain the stability of the power supply system (Kazmi *et al.*, 2019). SSA is plagued by an electricity energy crisis characterised by frequent and long periods of load-shedding (Amoah, Ferrini and Schaafsma, 2019; Kazmi *et al.*, 2019; Nkosi and Dikgang, 2018). For example, in Zambia, the energy crisis from 2015 (Kesselring, 2017; Ngoma *et al.*, 2018) has seen household power rationing lasting between 8 and 12 hours per day. The energy crisis in South Africa and the consequent load-shedding have plagued the country on and off since 2007 (Bohlmann and Inglesi-Lotz, 2021). It is projected that the energy crisis in the region will exacerbate due to an increase in demand of up to 4% by the year 2040 (Ouedraogo, 2017). Other regions equally experience load-shedding, with Pakistan being quite prominent for load-shedding with periods of up to 12 hours (Kazmi *et al.*, 2019). In Pakistan, Jabeen *et al.* (2019) found that load-shedding significantly influenced the intention to use renewable energy technologies. In a study linking willingness to pay for electricity and the duration of electricity load-shedding in South Africa, it was found that willingness to pay increased with an increase in the duration of load-shedding (Nkosi and Dikgang, 2018). Similarly, it is expected that the extent of load-shedding will influence peoples' attitude to adopt solar energy technologies. Considering the significance of the energy crisis facing SSA and other parts of the developing world, it is worthwhile to assess the effect of electricity load-shedding on the intention to adopt solar energy systems especially that very few studies have researched the relationship.

Few studies have focused on the effect of trust in the solar energy systems on the intention to adopt the technologies. However, trust has been reported to affect perceptions and beliefs (Park and Ohm, 2014). Fornara *et al.* (2016) found that trust in information from friends/relatives and neighbours was a powerful predictor of the intention to use renewable energy devices. Hardly any studies have focused on the effect of trust in solar energy solutions on the intention to adopt

them. Therefore, it is necessary to assess the effect of trust on the intention to adopt the technologies. In contrast to other studies, the current study operationalised the concept of trust as the amount of trust respondents had in solar energy solutions.

Based on the literature review, a number of factors that affect the intention to adopt solar energy solutions were identified. These include, *inter alia*, attitude towards the solar energy systems, PBC, subjective and social norms, perceived benefits of the systems, trust in the systems, perceived risks associated with the systems, cost, prevalence of electricity load-shedding and knowledge about the solar energy systems. These are the factors that were examined in the study, and the resulting conceptual model is shown in

Insert Figure 1.

Insert Figure 1: Research Conceptual Model

Methods

Study design and data collection

This study aimed to establish the factors that influence the intention to adopt solar energy systems by households in Zambia's urban areas. Data were collected from adult members of households who contributed towards the income of the households. Age, having an income and contributing to the income of the household were used to verify the eligibility of the respondents to participate in the survey. The data were collected from the major urban cities of Lusaka, Copperbelt, Central, Southern and North-western provinces of Zambia. The five provinces form the hive of economic activities and collectively account for over 55% of the population and contribute 82.2% to the national gross domestic product (Central Statistics Office, 2017, 2018). Access to electricity in these regions is essential for normal household functioning. However, recent increased demand, which exceeds the supply of electricity from the national grid, means that households have to make a conscious decision regarding the possibility of adopting solar energy.

Owing to the difficulty in finding a single reliable database for sampling in Zambia (Zulu-Chisanga, Chabala and Mandawa-Bray, 2020) and the likelihood of not finding heads of households at their houses during data collection, this study relied on convenience sampling and snowballing. An online self-administered questionnaire was distributed to various public and private organisations for their members who were key decision-makers in their households to complete. The use of an online questionnaire provided a feasible, safe and convenient way of collecting data during the COVID-19 health pandemic (Dodds and Hess, 2020; Torrentira, 2020). Google Forms© was the online questionnaire platform of choice. Snowballing was implemented by asking the initial target groups to forward the link of the questionnaire to others.

A pre-test was done on the questionnaire to check for reliability and validity of the scales. This was done by deactivating the link to the questionnaire after receiving 80 responses. Exploratory Factor Analysis (EFA) and validity and reliability tests were done to test the instruments. Minor adjustments were then made to the instruments in line with the results of the pre-test. The link was activated again to continue with the data collection. The initial 80 responses were included with the main survey because the minor adjustments mainly composed of deleting a few

individual items, which did not factor with the appropriate scale. An initial total of 963 questionnaires were returned. After data screening for respondent eligibility, 16 questionnaires did not meet the criteria of age, having an income and contributing to the income of the household. Therefore, the 16 questionnaires were omitted from the analysis by listwise deletion, leaving 947 fully completed and eligible questionnaires. The majority of the respondents (71.1%) were the sole main provider in their households. The average age of the respondents was 34 years, with the majority being male (61.2%), had a tertiary level of education (91.4%) and were in some form of gainful employment (81.6%). The majority lived in rented houses (76.5%) that were standalone (50.6%) or semi-detached (21.3%). On average, each household had about five people.

Measures

Five out of the seven scales for the study were adopted from existing scales and adapted to the local context. Scale adaption was undertaken after a pilot study aimed at checking the questionnaire items' suitability for the Zambian context. These are the scales for perceived trust, perceived risk, perceived cost, and knowledge which were adopted from Park and Ohm (2014). Minor grammatical adjustments were made to scales by Park and Ohm (2014) to make them suitable for the current study. The scales from the TPB considered the conceptualisation and operationalisation of constructs based on the definition by Ajzen (1991). For example, items measuring subjective norms were obtained by asking respondents to rate the extent to which "important people" would approve or disapprove of their intention to adopt solar energy solutions. Care was taken to ensure that all the items were worded as simply as possible so that all the respondents could understand them. This ensured that even constructs that are rather technical and not in common language used by the respondents were understood. Sample items for the resulting scales are shown in Table 1. The instruments were anchored on a 5-point Likert scale with 5=strongly agree; 4=agree; 3=neutral; 2=disagree; and 1=strongly disagree. EFA was used to establish the internal validity of the scales. All the study variables showed good internal reliability with their respective Cronbach's alpha values being above the recommend 0.7 thresholds (Hair *et al.*, 2010).

Insert Table 1: Research instrument sample items

Results

The results were analysed using multiple linear regression (MLR). The relevant parametric assumptions for MLR were checked prior to conducting the analysis, and these included singularity, multicollinearity, outliers, normality, linearity and homoscedasticity. Correlation analysis results in Table 1 shows that no independent variables were highly correlated, indicating that singularity was met. Multicollinearity was checked using the Variance Inflation Factor (VIF), and all the values were below the maximum recommended threshold of 10 (Hair *et al.*, 2010). Multivariate outliers were checked using Mahalanobis distance scores. There were no outliers in the data. Normality, linearity and homoscedasticity tests were done using residual and scatter plots (Hair *et al.*, 2010; Pallant, 2020). Table 2 shows the means, standard deviations and correlations of all the variables in the study. Overall, the correlations among the variables were relatively moderate, ranging from 0.192 to 0.675.

Insert Table 2: Variable Statistics

The control variables, respondent's gender, household type and household status, were entered first in Model 1, followed by the independent variables in Model 2. In model 1, the results indicate that there is a collective influence of gender, accommodation status and type of house on the intention to adopt solar energy solutions ($R^2 = 0.024$, $F(3,943) = 7.727$, $p < .001$). The main variables: attitude, PBC, subjective norms, social norms, benefits, trust, risks, cost, knowledge and load-shedding, were added in model 2, leading to a statistically significant increase in the variance explained ($R^2 = 0.499$, $p < .001$). The results indicate that collectively, these variables significantly predicted the variance in the intention to adopt solar energy solutions in Zambian households ($R^2 = 0.523$, $F(13,933) = 78.812$, $p < .001$). The most important predictor of intention to adopt solar energy solutions was attitude (b=.251, p< .001), followed by subjective norms (b=.179, p< .001), benefits (b=.143, p< .001), trust (b=.119, p< .001), knowledge (b=.098, p< .001) load-shedding (b=.076, p< .001 and social norms (b=.069, p<.05). PBC, risks and cost were not statistically significant predictors of intention to adopt solar energy solutions.

Insert Table 3: Regression Results

Discussion

Attitude towards solar energy solutions

Attitude towards solar energy solutions had the highest influence on the intention to adopt solar energy solutions. Therefore, when individuals have a positive attitude towards solar energy solutions, they are more likely to have intentions of adopting the technologies. This is consistent with the TPB and with many other studies (e.g. Abreu, Wingartz and Hardy, 2019; Jabeen *et al.*, 2019; Kim *et al.*, 2014; Korcaj, Hahnel and Spada, 2015; Lundheim *et al.*, 2021; Perri, Giglio and Corvello, 2020; Ru, Wang and Yan, 2018). There were no studies found which reported that attitude did not influence the intention to adopt renewable energies. Therefore, it appears that literature is unanimous that the attitude towards renewable energies is an essential predictor of the intention to adopt renewable energy solutions. Therefore, measures aimed at increasing the adoption of solar energy solutions should focus on increasing the attitude towards solar energy solutions.

Subjective norms

Subjective norms were the next most important predictor of intention to adopt solar energy systems. Therefore, the perception of the views of important and influential people influences intention to adopt solar energy systems. This means that when important revered individuals exhibit favourable views towards solar energy systems, people are more likely to have intentions of adopting the systems. This is in tandem with the TPB and a number of empirical studies (e.g. Jabeen *et al.*, 2019; Korcaj, Hahnel and Spada, 2015; Perri, Giglio and Corvello, 2020; Ru, Wang

and Yan, 2018). However, it is also in contradiction with some empirical studies (e.g. Abreu, Wingartz and Hardy, 2019; Lundheim *et al.*, 2021). The results are consistent with the argument that affluent societies may be more influenced by subjective norms because they are more likely to revere, envy and emulate influential people. While the current study is set in a developing country, the study sample comprised of upper-middle-class citizens because the target population was individuals with access to either email or social media through a smartphone. This means that the sample selected is relatively affluent and so was expected to be influenced by subjective norms based on the argument in the literature section. However, it should be noted that this argument alone may not fully explain the conflicting results relating to subjective norms and the intention to adopt solar energy solutions. This is because a study by Abreau et al. (2019) found a non-significant association in a sample that would be considered affluent. Therefore, this interpretation of the results should be taken with caution. Notwithstanding, the result has implications for Zambia in that measures aimed at improving the adoption of solar energy solutions could use the influence of important revered individuals to garner support for any interventions.

Perceived benefits

Perceived benefits attributed to using solar energy solutions were found to influence the intention to adopt the solution. This means that an increased perception of the benefits of solar energy solutions increases the intention to adopt them. However, this contrasts with findings by Irfan et al. (2021) that beliefs about the benefits of renewable energy did not significantly influence the intention to adopt renewable energies in Pakistan. This was attributed to a limit in the level of knowledge about the benefits of renewable energy. Considering that the conceptualisation of perceived benefits of solar energy solutions in the current study is relatively similar to that by Irfan *et al.* (2021), it may well be that the respondents in the current study are more knowledgeable about the benefits of renewable energy solutions. This finding suggests that efforts aimed at improving the uptake of solar energy solutions should emphasise the benefits of using solar energy solutions. This would likely also lead to an improved attitude towards the solutions and so further increase their adoption.

Perceived trust

Perceived trust in solar energy systems was found to influence the intention to adopt the solutions. This means that the intention to adopt solar systems increases when people trust the solutions to meet their demands and expectation. Trust in the solar energy solutions is particularly important for regions experiencing severe episodes of load-shedding like the SSA because trust has been eroded from the grid-supplied electricity. It follows that any systems which can be relied upon to provide electricity would be preferred and hence the importance of trust in the solar systems on the intention to use them. This argument is supported by research that shows that trust affects perceptions and beliefs (Park and Ohm, 2014). Logically, a good perception and belief of solar energy solutions would increase the intention to adopt the solutions. This is consistent with a related study by Fornara *et al.* (2016), who found that trust in information from friends/relatives and neighbours was a powerful predictor of the intention to use renewable energy devices. Therefore, measures aimed at improving the adoption of solar energy in Zambia should also focus on highlighting that solar energy solutions are reliable and trustworthy sources of energy.

Knowledge of solar energy systems

Knowledge of solar energy systems was found to influence the intention to adopt the systems. This means that the more knowledgeable a person is about solar energy solutions, the greater will be their intention to adopt the solutions. This resonates with findings by Huang *et al.* (2020) that literacy training had a significant influence on the use of solar systems. However, the findings are in contrast to those by Jabeen *et al.* (2019) that environmental knowledge and awareness did not influence the consumers' intention to use renewable power generation technologies. This contradiction in results may be due to the difference in the conceptualisation of the construct for knowledge. The current study conceptualised knowledge as the extent of knowledge about renewable energies in general and solar energy in particular, while Jabeen *et al.* (2019) looked at environmental knowledge. It may be the case that general environmental knowledge and concern for the environment may not be enough to influence the intention to use renewable energy, while being knowledgeable specifically about available solar energy solutions may influence the intention to adopt them. Therefore, efforts aimed at improving the use of solar energy solutions should also focus on increasing the amount and level of knowledge about available solar energy solutions in the target population.

Extent of load-shedding

The extent of load-shedding was also found to influence the intention to adopt solar energy solutions. Considering how the concept of load-shedding was conceptualised in this study, respondents had increased intentions to adopt solar energy solutions because of the extent to which they were affected by power outages attributed to load-shedding. This is consistent with findings by Jabeen et al. (2019). It was expected that load-shedding would be one of the largest influences on the intention to use solar energy solutions considering the severity of load-shedding in the study area. However, while it significantly predicted the intention to adopt solar energy solutions, it ranked second last among the seven variables found to be significant. Nevertheless, the finding corroborates findings from Pakistan about the relevance of load-shedding to the intention to use solar energy solutions in regions with severe episodes of load-shedding. Therefore, measures aimed at improving the adoption of solar energy may emphasise that solar energy solutions are a solution to the rampant power outages due to electricity load-shedding.

Social norms

Social norms had the least influence on the intention to adopt solar energy solutions. Notwithstanding, this means that feelings of moral obligation to adopt solar energy solutions influence the intention to do so. This is consistent with the TPB and some studies (cf. Abreu, Wingartz and Hardy, 2019; Lau *et al.*, 2020). However, the finding is in contrast to other findings (e.g. Fornara *et al.*, 2016). Fornara *et al.* (2016) hypothesised that social norms would positively influence the intention to adopt solar energy solutions even though the data subsequently rejected the hypothesis. It was noted that the fact that the study region had received decades of economic incentives may have influenced some of the findings. Because the results of the current study are consistent with those by Lau et al. (2020), whose context is similar, the finding suggests that the presence of contextual moderating circumstances may weaken the effect of social norms on behavioural intention. Notwithstanding, in Zambia, measures aimed at improving solar energy adoption may appeal to social norms by highlighting the moral obligation to contribute to the use of sustainable energy.

PBC and perceived cost

PBC did not have any significant influence on the intention to adopt solar energy solutions in Zambia. This means that whatever level of control people felt they had over perceived impediments to the adoption of solar energy solutions did not subsequently influence their intention to adopt the solar solution. This is consistent with some studies (cf. Abreu, Wingartz and Hardy, 2019; Huang *et al.*, 2020). However, it is contrary to the TPB and some other studies (cf. Jabeen *et al.*, 2019; Lundheim *et al.*, 2021; Perri, Giglio and Corvello, 2020; Ru, Wang and Yan, 2018). The findings appear to support the argument that the behavioural intention of populations low on PBC will be low. This partly explains the conflicting results pertaining to PBC and the intention to adopt solar energy solutions. Some doubt about the validity of this argument remains because findings by Abreu et al. (2019) seem to contradict this argument, as explained in the literature section. This suggests that while the level of PBC may explain the conflicting results pertaining to PBC and the intention to adopt solar energy solutions, other factors also play a role in the relationship.

This study also found that perceived cost did not influence the intention to adopt solar energy solutions. This finding is surprising because it is counter-intuitive considering that solar energy is more expensive than the more common hydro-power energy per kWh. The findings are also contrary to other studies, which consistently found that cost influenced the intention to adopt solar energy systems (e.g. Irfan *et al.*, 2021; Jabeen *et al.*, 2019; Kim *et al.*, 2014; Qureshi, Ullah and Arentsen, 2017). It is worth noting that the mean score for the cost variable was 2.9, meaning that respondents were on average close to neutral about the cost of solar energy systems being an inhibiting factor. This suggests that, on average, respondents did not consider the cost of solar energy solutions to be high, and so it did not affect their intention to adopt the solutions. This resonates with the fact that the cost of solar energy systems has drastically reduced over the last several years (Schwerhoff and Sy, 2020).

Conclusion

This study set out to assess factors that influence the intention to adopt solar energy solutions in Zambia. Factors identified from the literature as having an influence on the intention to adopt renewable energy technologies were identified. Using multiple linear regression analysis, the factors were assessed for their significance in predicting the intention to adopt solar energy solutions. The study also comments on some findings which appear to be divergent.

The study has shown that, in Zambia, attitude towards solar energy solutions is the most important predictor of the intention to adopt solar energy solutions followed by subjective norms. The study also infers that subjective norms in affluent populations more strongly predict behavioural intentions than in underprivileged populations. However, this conclusion requires further validation. Perceived benefits and perceived trust of the solar energy solutions are also important predictors of the intention to adopt solar energy solutions. Knowledge about solar energy technologies and the extent of load-shedding experienced in communities also predict the intention to adopt solar energy solutions. Specifically, knowledge should be about available solar energy solutions as opposed to general knowledge about renewable energies and their relevance. Social norms have the least influence on the intention to adopt solar energy solutions in Zambia. The study infers that social norms are very likely moderated by contextual factors, which likely diminish their effect. However, this conclusion requires further validation as well. PBC, perceived risk and perceived cost did not significantly influence the intention to adopt solar energy solutions in Zambia. Further, the study infers that behavioural intention will be low in

populations with low PBC and vice versa. However, this conclusion requires further validation as well.

The findings have a number of implications for Zambia. Efforts aimed at increasing the adoption of solar energy solutions should consider the relative importance of these factors in influencing behavioural change. Therefore, more attention should be paid towards improving people's attitude towards solar energy solutions if the adoption of solar energy solution is to be improved. Further, influential figures in society should be used in advertising solar energy solutions while emphasising the benefits and trustworthiness of the solutions to take advantage of the importance of subjective norms and the perception of benefits and trust on the intention to adopt the solutions. Such ventures are likely to improve the attitude towards the solutions and also increase knowledge on available solar energy solutions, which are relevant to the intention to adopt solar energy solutions. These measure can be initiated by the government entities tasked with increasing the adoption of solar energy solutions and private entities and associations engaged in supplying solar energy solutions. These measures are applicable to most countries in the SSA and developing countries in general because they often exhibit very similar contexts, including severe power shortages leading to load-shedding. Government entities responsible for increasing the adoption of solar energy in Zambia can adopt these recommendations, including the Department of Energy in the Ministry of Energy responsible for developing policy energy and the Rural Electrification Authority (REA) responsible for increasing access to electricity in rural areas. Private entities include the Solar Industry Association of Zambia, the Renewable Energy Association of Zambia and off-grid solar energy solution providers.

However, the results are subject to some limitations. The most significant one is that the study collected data conveniently from individuals who had access to email or smartphones. Subsequently, the results are rather biased towards more affluent people in an otherwise low-income country. Therefore, the results lack external validity and may not necessarily be generalisable to the wider population in Zambia or SSA. Therefore, the recommendations need to be taken with some caution. Besides addressing the limitations, further research could focus on establishing underlying reasons for the differences in the findings in the extant literature, including the effect of culture and different social-economic backgrounds on the intention to adopt solar energy solutions. Such a study can produce results relevant to local contexts.

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Perceptions and Beliefs which influence the intention to use solar energy solutions in the Zambia Housing Sector

Tables

Table 4: Research instrument sample items

Perceived Benefits	
1	Renewable energy technologies may lead to new and better ways to clean up the environment
2	Renewable energy technologies may help us develop increased industrial competitive advantages
3	Renewable energy technologies may lead to new and better ways to treat and solve social problems
Perceived Trust	
1	I have trust in renewable energy technologies in Zambia
2	I believe that renewable energy technologies can improve our energy generation industry successfully significantly
3	I feel that renewable energy technologies and generators installed available in Zambia are generally reliable
Behavioural Intention	
1	I plan to use renewable energy technologies such as solar and wind within the next twelve months
2	I plan would consider to using less Zesco electricity in my household in preference for solar energy
3	I would consider using less I plan to use less charcoal in my household in preference for solar energy over the next twelve months
Attitude	
1	Applying Use of renewable energy technologies is extremely good for my household
2	Applying Use renewable energy technologies is extremely wise for my household
3	I strongly agree/support with the use of renewable energy technologies
Perceived Risk	
1	Renewable energy technologies and plants in Zambia are not safe
2	Renewable energies such as solar power are unreliable
3	Renewable energies such as solar power are prone to failure
Perceived Cost	
1	I think the equipment cost of employing renewable energy technologies and generators is expensive
2	I think the maintenance cost of using renewable energy technologies and generators is expensive
3	It takes a considerable amount of effort and cost to use renewable energy technologies and generators.
Perceived Behavioural Control	
1	It is entirely up to me to start using solar energy
2	The decision to use solar energy is beyond my control because I cannot afford it
3	The decision to use solar energy is beyond my control because I cannot access it
Subjective Norms	
1	Most people who are important to me think it would be a good idea for me to start using solar energy
2	Most people who are important to me would approve if I start using solar energy
3	Most people who are important to me want me to start using solar energy
Social Norms	
1	Generally, people feel that solar energy is the way to go
2	Most people are switching to solar energy
3	A lot of people are in favour of switching to solar energy
Electricity Load Shading	
1	Because of load shading, I would prefer to use solar electricity
2	Because of load shading, I would prefer to a generator
3	Because of load shading, I predict that our society will use solar energy technologies more
Knowledge	
1	I am familiar with renewable energy sources and technologies
2	I am familiar with electricity from renewable energy technologies from source including the sun, wind and water
3	I am knowledgeable about renewable energy

Table 5: Variable Statistics

	Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10
1	Intention	3.539	0.982										
2	Attitude	3.887	1.048	0.635**									
3	PBC	2.493	0.888	-0.017	-0.057								
4	Subnorm	3.444	0.932	0.540**	0.503**	-0.021							
5	Socialnorm	3.489	0.961	0.497**	0.504**	-0.022	0.589**						
6	Benefit	3.726	0.964	0.587**	0.679**	-0.001	0.496**	0.478**					
7	Trust	2.948	0.878	0.553**	0.635**	-0.039	0.454**	0.461**	0.586**				
8	Knowledge	2.324	0.819	0.498**	0.525**	-0.010	0.431**	0.449**	0.506**	0.511**			
9	Risk	3.350	0.939	0.120**	0.130**	-0.011	0.148**	0.102**	0.121**	0.130**	0.111**		
10	Cost	3.703	0.907	0.222**	0.302**	0.008	0.230**	0.244**	0.262**	0.150**	0.263**	0.232**	
11	Loadshedding	3.466	1.075	0.338**	0.337**	-0.033	0.341**	0.327**	0.344**	0.275**	0.213**	0.041	0.176**

** Correlation is significant at the 0.01 level (2-tailed).

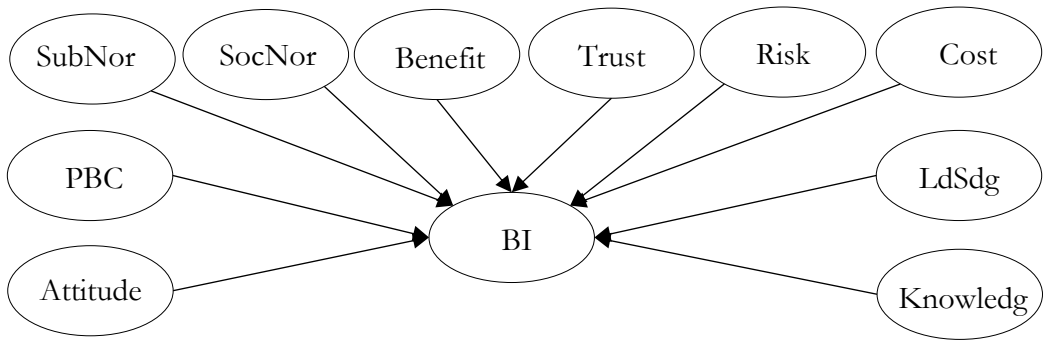
Table 6: Regression Results

	Model 1		**Model 2**	
Variables	**B**	**Sig.**	**B**	**Sig.**
Constant	3.151	0.000	0.024	0.887
Gender	0.012	0.854	0.068	0.145
House status	-0.033	0.523	0.011	0.766
House type	0.182	0.000	0.051	0.065
Attitude			0.251	0.000
PBC			0.012	0.639
Subjective norm			0.179	0.000
Social norm			0.069	0.026
Benefit			0.143	0.000
Trust			0.119	0.000
Knowledge			0.098	0.000
Risk			-0.011	0.712
Cost			-0.014	0.624
Load shedding			0.076	0.005
F		7.727**		78.812**
Model R^2		0.024		0.523
Adjusted R^2		0.021		0.517
Change in Adjusted R^2				0.499*

*$p<.05$; **$p<.001$

Perceptions and Beliefs which influence the intention to use solar energy solutions in the Zambia Housing Sector

Figures



*PBC=Perceived behavioural control; SubNorm=Subjective norms; SocNorm=Social norms; LdSdg=Load shedding

Insert Figure 2: Research Conceptual Model